

ACTIDYN SA*Centrifuges and Simulators*

7867-EN-01

068171-96-C-9010

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US ARMY CORPS of ENGINEERS**WATERWAYS EXPERIMENT STATION****CIVIL ENGINEERING CENTRIFUGE****INSTALLATION COMMISSIONING
and
SCIENTIFIC INVESTIGATION**

Final

DISTRIBUTION STATEMENT A**Approved for public release
Distribution Unlimited**

DTIC QUALITY INSPECTED 2

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December, 1995
February, 1996
December, 1997

19980126 074

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I Introduction

The WES civil engineering centrifuge designed and built by Acutronic France, shall be, when commissioned not only the world strongest ever built centrifuge but also the world most performing centrifuge in its size in terms of maximum acceleration

The installation, commissioning, and scientific investigation of this unique system was contracted to Actidyn SA, a company formed by the former design team of the centrifuge, on November 13, 1995.

II Initial phase, centrifuge transport and installation.

II,1 Transportation

The transport from France to Vicksburg was contracted directly by the corps of engineer to an independent contractor and was indeed well executed except for the transportation of the centrifuge itself between New Orleans and Vicksburg.

Road transportation proved difficult for two reasons the state imposed weight limit and the design weakness of the two first trucks which unsuccessfully tried to transport the load.

The centrifuge was then partially unpacked and mechanically disassembled under my supervision, in New Orleans harbor, in order to reduce its weight. The cargo was finally on the road after two days of efforts.

II,2 Craning, Installation

By far the most critical phase during installation the craning operation went extremely well and was terminated on schedule despite the late arrival of the centrifuge itself, for reason mentioned before.

All goods received were in excellent condition and except for a few minor parts missing (screws, bolts), which were shipped separately by Acutronic through Actidyn, the centrifuge assembly went as well as possibly be.

All major parts were craned and in place before Thanksgiving, the building roof was set back in place on November 28 ending the crane operation.

The centrifuge room has geometrical distortion slightly in excess of Acutronic requirement almost ± 10 mm error in circularity and centering in lieu of ± 5 mm as required. Perfect centering was not possible but an acceptable compromised was achieved, which correspond to an offset of the centrifuge axis of rotation of less than 3 mm with respect to the theoretical center of the centrifuge room.

The alignment of the centrifuge axis of rotation versus the gear reducer drive axis was measured as ± 0.1 mm, a near perfect alignment which shall ensure a very long life to the centrifuge major transmission elements.

II,3 Wiring, piping.

Most of the centrifuge wiring was executed on Saturday December 2, when I returned to France.

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Unfortunately no electrical test could be conducted as the main transformer could not be powered up in reason of some technical problems? with the building electrical installation.

90% of the centrifuge piping was also terminated and but for one missing fitting it would have been fully terminated.

User's slip rings and rotary joints are in place all user's mechanical interface were installed and available as of December 1st.

III Progress and works executed from December 1st, till December 23rd, 1995

Missing bolts were brought from France as said, and centrifuge final assembly and bolt tightening was executed as scheduled, yet the torque multiplier provided by WES proved to be difficult to use because of its size and weight, bolt tightening operation shall have to be redone with appropriate tool which Actidyn may bring back during next trip.

Wiring and piping was carried upon completion.

Design of the louvers control was made in France, which includes schematics and wiring diagrams.

Some damage was made to the centrifuge counterweights control system by rain water which drops into the electrical slip rings containment structure, and the electrical cabinet located underneath. The counterweights position readout and control system failed afterwards, circuits were repaired twice, but failed again the entire system is to be replaced.

During the last week of December the centrifuge drive was turned on, after the lubricating system was made operational and the tubes were filled with oil.

A leak was detected at the extremity of both tubes, preventing the auto-balancing system to be further tested.

The centrifuge drive was tested during the last five days of test under no load condition at speed up to 150 Rpm, in manual control. At speed of 150 Rpm and above, the upper bearing began to leak forbidding further test at higher speed to be carried out.

As of December 23rd the centrifuge was nearly totally completed, the program delayed by about one week but for the upper bearing modification which was estimated to add a further delay of about ten days.

IV Progress and works executed from January 4, 1996, till February 17, 1996

The upper section of the centrifuge was removed as well as the transmission diaphragm. New parts executed by WES, per Actidyn design were set in place in replacement of the original tubes configuration.

Upper parts of the centrifuge was set back which includes slip-rings and optical fiber. The centrifuge was then run at rate up to 150 Rpm, while system integration was completed, and strain gage wiring finished including arm channels wiring, etc...

Louvers and fan wiring were finished and tested, although the fan could not be run but briefly due to the large amount of dust still present in the building.

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The program was interrupted, due to the fact that the Reliance engineer was not available, once the strain gage wiring undertaken by WES and Actidyn was terminated.

Test were resumed on February the 8th and the following days, after final bolts torque tightening was made with the appropriate torque wrench hand carried from France.

Building finish works, painting mostly, slowed the process a bit.

All safety feature including door locks, TV cameras, emergency switches, were installed and from then on the centrifuge rotation was only made possible after and only after the centrifuge building was evacuated, all door closed, the safety locks engaged.

According to the plan, although never set in written, established by WES and ANS&A, in early January, test were limited to 1000 kg payload up to 250 g's, and 7000 kg up to 150 g's.

The centrifuge was loaded with 1000 kg and acceleration was progressively increased up to 150, 200 then 250 g's.

Independent strain gage monitoring was performed by WES/ANS&A and Actidyn, except for the platform strain gages were located in similar or symmetrical locations.

No plastic deformation was measured during these test, and once calibrated, the stresses measured did correlate with calculated stress.

Load was then increased to 7000 kg, mainly for the purpose of adjusting the drive to the largest possible inertia. The command ramp and various internal parameters to the drive were adjusted, in order to warrant smooth, controlled, and repeatable start, stop, with balanced drives. This was achieved without major difficulties.

On Friday February the 16 th a test was conducted which aimed to 7000 KG at 150 g's. At acceleration between 140 and 150 g's, a brutal change was noticed in some of the strain gages output. The centrifuge was consequently stopped, for physical examination.

Both aerodynamic shrouds, front and rear, were found with cracks, which were later explained by the platform supports strain.

Some test were conducted at lower acceleration, after the shrouds were removed. As expected the platform and supports reacted well (elastic behavior) as monitored by the measuring system.

All test were stopped until further analysis of the phenomena would be performed. A safe operating envelop, that allows scientific experiment to be performed was defined and proposed to WES on February 23rd, as an interim measure until exact causes of the problems are understood and curative action undertaken.

V Progress and works executed from March, 1996 till June 1997

From March 1996 till October 1997, I was involved as well as other engineers from ACTIDYN, directly or indirectly in the reconstruction of the failing parts, even so this was not part of my original contract.

Replacement parts were shipped to WES during the month of June and successfully integrated in replacement of original parts by WES personnel during July and August.

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VI Final commissioning test September 10th, till September 14th, 1997

A four days test campaign was undertaken at WES in order to investigate the not yet explored operating domain of the centrifuge and the technical compliance of new replacement parts with their design criteria.

This basically covered centrifuge operation above 250g's up to 350g's at full load.

Full load capacity was first proven with a payload of 8.000 kg at 150g's a world premiere !

Measured stress and strain were all within prediction clearing at once all previous questions .

Then the centrifuge was unloaded and progressively ran up to 350g's without the aerodynamic shrouds despite the additional aerodynamic drag caused by the removal of the aerodynamic shrouds the drive developed enough power to achieve the 350g's target (355 g's indeed).

Progressively 2000kg of payload were added to the platform and the centrifuge was repeatedly spun up to 350g's and run at such acceleration for over 20 minutes without any noticeable event.

At this stage all parties present agreed to pronounce final commissioning achieved and centrifuge ready for operational use within its original design specification without limitation.

VII Conclusions.

All technical goals and performance set for the WES civil engineering centrifuge are finally met which makes this research tool a unique world class facility.

My last action is schedule to take place on early January in Vicsburg with the replacement of the strain gauged feet, this operation shall conclude the present research contract.

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ATTACHMENT I

Important Notices :

1/ Operation of the centrifuge is always hazardous, and despite the precaution taken during the building design and construction of the building, the building cannot and should not be considered as an absolute safety device, which it was never intended to be.
In consequence it is our strong advice that the building, and in particular the model preparation room should remain unmanned, while the centrifuge is in rotation.

2/ The two main access doors, for personnel, are equipped with safety locks which are part of the safety management system, yet they are still two possible human access which are not yet secured, the lift and the trucks rolling door. It was always considered that these two devices and in addition the hydraulic lifting table should be electrically shut down and in their down position, before the centrifuge could be started (emergency stop line). This is still to be done, and must be done as soon as possible.

3/ Safety interlocks.

The preparation rolling door, the hydraulic platform lift, the building access lift must be interlocked with the centrifuge safety management system.

One simple way consist of maintaining the centrifuge emergency stop line open as long as :

- 1/ The rolling door is closed, and its electrical power switch is turned off.
- 2/ The hydraulic platform lift is down, and its hydraulic pressure line is turned off (fail safe valve).
- 3/ The access lift is down, and its electrical power switch is turned off.

Operating the centrifuge without this being done is at the operator risk, and modification should be done as quickly as possible.